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First record of *Crenicichla semifasciata* (Heckel, 1840) (Teleostei: Cichlidae) in the upper Rio Paraná basin, Brazil

Camilo A. Roa-Fuentes[1*], **Jaquelini O. Zeni**[1], **Henrique R. Varella**[2], **Francisco Langeani**[1] and **Mariana C. Molina**[1]

1 UNESP, Universidade Estadual Paulista "Júlio de Mesquita Filho", Instituto de Biociências, Letras e Ciências Exatas, Departamento de Zoologia e Botânica, Laboratório de Ictiologia. Rua Cristóvão Colombo, 2265, Jardim Nazareth, 15054-000 São José do Rio Preto, SP, Brazil
2 Museu de Zoologia da Universidade de São Paulo, Caixa Postal 42494, 04218-970 São Paulo, SP, Brazil. Pós-Graduação em Zoologia da USP
* Corresponding author. E-mail: camilo.roa@gmail.com

Abstract: *Crenicichla semifasciata* was described from the Rio Paraguai in "Caiçara" (near Cáceres, Mato Grosso, Brazil) and has been reported in the Rio Paraguai and lower portion of the Rio Paraná downstream of the Itaipu hydroelectric dam, but considered absent in the upper Rio Paraná and in the Rio Uruguai basin. In this paper, we document the first record of *C. semifasciata* in a first order stream of the Ribeirão Buritis, tributary of the Rio São José dos Dourados, upper Rio Paraná basin.

Key words: fish introduction, non-native species, Rio São José dos Dourados, La Plata basin

Crenicichla Heckel, 1840, the richest genus of Cichlidae in South America with 86 species (Kullander 2003; Eschmeyer 2014), requires further taxonomic and ecological study. Taxonomic revisions and documentation of species geographic distributions are especially needed to inform conservation policies. The genus *Crenicichla* has highest species richness in rivers of the Amazon basin and Guyanese highlands, however approximately one third of currently valid species inhabits the three major river drainages of the Rio de La Plata basin, viz., Rio Uruguai, Rio Paraguai and Rio Paraná. Lucena and Kullander (1992), followed by Lucena (2007), recognized thirteen species of *Crenicichla* from the Rio Uruguai, and found a high degree of endemism in the middle-upper Uruguai basin, with ten endemic species. Seven species of *Crenicichla* are distributed in the coastal drainages of Southeast and Southern Brazil, forming a distinct fauna without any representative in the adjacent rivers of the La Plata or São Francisco basins (Kullander and Lucena 2006; Mattos et al. 2014).

A recent taxonomic study of the genus in the Rio Paraguai and Paraná drainages (Varella 2011; unpublished M.Sc. dissertation) documented thirteen valid and four undescribed *Crenicichla* species. Subsequently, two other species were described (Casciotta et al. 2013; Kullander and Lucena 2013), which resulted in 19 species from the Paraná and Paraguai river basins. *Crenicichla semifasciata* (Heckel 1840), described from the rio Paraguai in Caiçara (near Cáceres, Mato Grosso, Brazil) has been reported in the Rio Paraguai and lower portion of the Rio Paraná, below the Itaipu hydroelectric dam, but has not been recorded from the upper Rio Paraná and Rio Uruguai basins (Lucena and Kullander 1992; Casciotta et al. 2013). Here, we document the first record of *C. semifasciata* in the upper Rio Paraná basin, and discuss the potential explanations for its occurrence in the area.

During a 2013 investigation of the ichthyofauna of the Rio São José dos Dourados and Rio Turvo-Grande sub-basins (upper Rio Paraná basin) in the São Paulo state, 86 watersheds were surveyed (Figure 1). Surveys were permitted by the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA5580-1/11435). Twenty-one specimens of *C. semifasciata* (38–110.9 mm SL) were sampled from a first-order stream of the Ribeirão Buritis, a tributary of São José dos Dourados, 20°37′44″ S, 050°22′19″ W, General Salgado municipality, São Paulo state, Brazil (highlighted in red in map of Figure 1), on 14 August 2013. These fishes were deposited in the Coleção de Peixes DZSJRP, Universidade Estadual Paulista, UNESP, São José do Rio Preto campus, under catalog number DZSJRP 19284 (available at: http://www.splink.org.br/).

For identification and comparisons, measurements and counts were taken from 11 adult specimens following the protocol of Kullander (1986). This sample could be considered enough to identify the species, as it includes all larger (adults) specimens captured. A list of comparative material examined can be consulted in Varella (2011) and Varella et al. (2012).

Crenicichla semifasciata (Heckel, 1840). General aspect and color pattern in Figure 2; morphometric and meristic data presented in Tables 1 and 2, respectively. There is a problem concerning the type material of *Batrachops semifasciatus* Heckel 1840, because no potential type specimen has been found in any ichthyological collection (Kullander 2003; H.R.V. pers. comm.). However, the identification of this species in rivers of the La Plata basin is relatively easy based on the original description and recent literature (e.g., Britski et al. 1999,

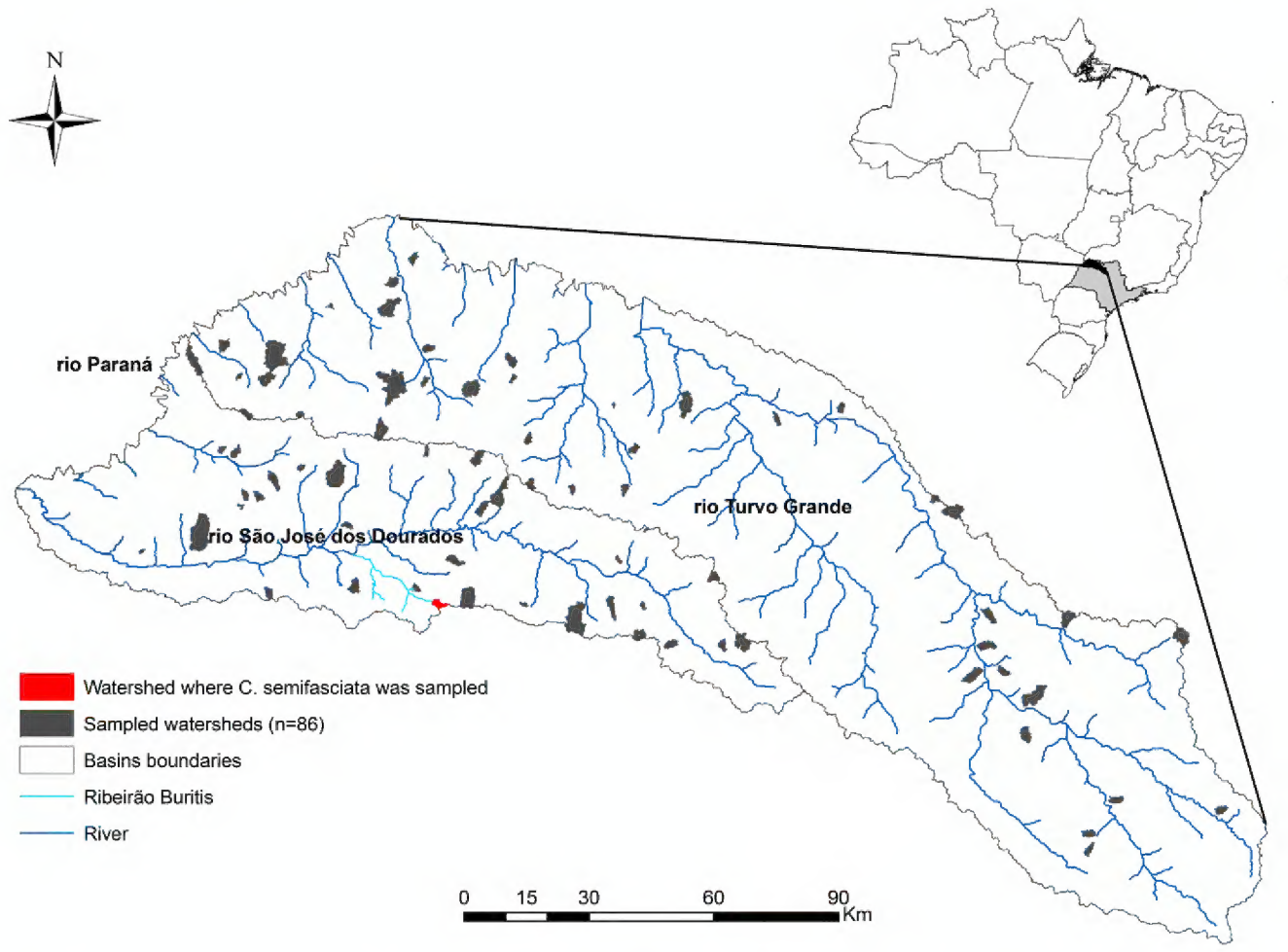

Figure 1. Study area with the 86 watersheds covered in collecting activities, rio São José dos Dourados and rio Turvo-Grande sub-basins, upper rio Paraná basin, São Paulo State, Brazil. Highlighted in red is the watershed where *Crenicichla semifasciata* was sampled.

Figure 2. *Crenicichla semifasciata*, DZSJRP 19284, 110.9 mm SL, from Ribeirão Buritis, rio São José dos Dourados drainage, upper rio Paraná basin. Lateral (above) and dorsal (below) views.

Table 1. Morphometry of *Crenicichla semifasciata* from upper rio Paraná. Standard length in millimeters, proportional measurements are means and standard deviations (SD) expressed as percent of standard length ($n = 11$).

	Min	–	Max	Mean	±	SD
Standard length (mm)	37.2	–	110.9	54.4	±	20.7
Body depth	21.5	–	24.1	22.2	±	0.8
Head length	30.2	–	33.0	31.7	±	1.0
Head depth	15.1	–	17.3	16.1	±	0.6
Orbital diameter	8.6	–	11.7	10.3	±	0.9
Interorbital distance	6.5	–	9.4	7.3	±	0.8
Snout length	6.3	–	8.0	6.9	±	0.6
Upper jaw length	8.9	–	11.8	10.1	±	0.8
Lower jaw length	14.2	–	16.1	14.8	±	0.5
Caudal peduncle depth	11.5	–	13.8	12.2	±	0.6
Caudal peduncle length	12.1	–	14.3	13.1	±	0.8
Last dorsal-fin spine length	11.8	–	13.6	12.6	±	0.6
Pectoral fin length	23.1	–	25.0	24.0	±	0.7

Table 2. Meristic counts of *Crenicichla semifasciata* from upper Rio Paraná (number of specimens in parentheses).

Scales in E1 row	60 (3), 62 (3), 63 (3) 64 (2)
Lateral line composition (upper/ lower branches)	24/11 (1), 24/12 (1), 25/10 (2), 25/11 (2), 25/12 (2), 26/10 (2), 27/11 (1)
Scale-rows between lateral lines	3
Dorsal fin composition	XXII.10 (1), XXIII.9 (1), XXIII.10 (3), XXIII.11 (3), XXIII.12 (1), XXIV.10 (2)
Anal fin composition	III.7 (5), III.8 (6)
Pectoral fin rays	17
Gill rakers on first gill arch	8 (6) or 9 (5) on ceratobranchial +1 in angle + 2 on epibranchial
Gill rakers on lower pharyngeal tooth plate	8 (3), 9 (3), 11 (2)
Teeth on oral jaws	one outer row and 2 or 3 inner rows of teeth

2007; Varella 2011). *Crenicichla semifasciata* is the only member of the *Crenicichla reticulata* group distributed in the La Plata basin. Species in this group are diagnosed by a robust, dorsoventrally depressed body, adults with teeth in outer row larger than teeth of inner rows and firmly fixed to jaws, flanks having horizontal dark stripes, and dense squamation covering almost the entire caudal fin (see Varella, 2011 for further comparisons and exceptions). Among species of this group, *C. semifasciata* is more similar to *C. reticulata* (Heckel 1840) and *Crenicichla stocki* Ploeg, 1991 by having a blunt snout with nostrils very close to the postlabial skin fold and a serrated posterior preopercular margin. *Crenicichla semifasciata* differs from those species by the pattern of horizontal stripes on the flank being less conspicuous or nearly absent, the body slightly shorter, and the number of scales along the body (E1 series) slightly fewer (55–65 according to Varella 2011; 60–64 in the material from upper rio Paraná vs. more than 66 in *C. reticulata* and *C. stocki*). Additionally, based on a single dissected specimen, *C. semifasciata* from upper Rio Paraná has stout pharyngeal jaws bearing some molariform teeth, a characteristic that distinguishes *C. semifasciata* from most species of the genus, according to Casciotta et al. (2013).

The stream where *Crenicichla semifasciata* was captured averages approximately 0.5 m width and 0.23 m depth, with grasses along its margins and substrate composed mainly of sand (Figures 3 and 4). The stream contains a series of small pools, and there is an artificial dam located approximately 130 m upstream from

Figures 3 and 4. Habitat of the stream reach where *Crenicichla semifasciata* was sampled. **3**: grasses (Poaceae) located inside of the stream pool and **4**: stream run.

our survey site. *Crenicichla semifasciata* was captured with: *Astyanax altiparanae* Garutti and Britski, 2000 and *Hoplias malabaricus* (Bloch, 1794) [Characiformes]; *Aspidoras fuscoguttatus* Nijssen and Isbrücker, 1976, *Corydoras aeneus* (Gill, 1858) and *Hypostomus ancistroides* (Ihering, 1911) [Siluriformes]; *Gymnotus sylvius* Albert and Fernandes-Matioli, 1999 [Gymnotiformes]; *Poecilia reticulata* Peters, 1859 [Cyprinodontiformes]; *Synbranchus marmoratus* Bloch, 1795 [Synbranchiformes]; and *Cichlasoma paranaense* Kullander, 1983 and *Satanoperca pappaterra* (Heckel, 1840) [Perciformes]. Most of these species are widely distributed in rivers of cis-andean South America or have distribution restricted to the upper Rio Paraná basin.

Natural occurrence of *Crenicichla semifasciata* in the upper Rio Paraná is unlikely. Since 1840, the upper Rio Paraná is one of the most studied river basins of Brazil (Heckel 1840), and this species has not been reported in the area. Also, dispersion from the middle portion of the Rio Paraná via Itaipu is implausible, because a basin-wide distribution would be expected. Thus, human introduction of *C. semifasciata* in this stream is probably the most feasible explanation. The species does not appear to be commonly targeted for fishing or the aquarium trade. However, it could have been unintentionally introduced through fish stocking of artificial lakes, such as the one situated upstream of the sampled site of *C. semifasciata*. This introduction probably was recent given that this stream and 94 other streams of the Turvo-Grande and São José dos Dourados sub-basins were previously sampled in 2003, and the species was not recorded (Casatti et al. 2009).

Most *Crenicichla* species are piscivorous (adult size classes in particular) and display aggression and territorial behavior, however there is large interspecific variation in feeding tactics and behaviors (Gibran et al. 2001; Montaña and Winemiller 2009; Burress et al. 2013). Gut contents from 10 adult specimens of *C. semifasciata* (51.6–110.9 mm SL) from the upper Rio Paraná were evaluated according to frequency of occurrence and dominance of food items. This species appears to be an insectivore, feeding on aquatic insects, with predominance of Tricoptera, Diptera and Ephemeroptera. Moreover, the dorso-ventrally depressed body of *C. semifasciata*, as in other species of the *reticulata* group, suggests foraging near the stream substrate. Among species of *Crenicichla* from the upper Rio Paraná, only *Crenicichla jupiaensis* has morphological characteristics suggesting the same feeding spectrum and behavior, however this species appears to be associated with faster flowing streams segments (Casciotta et al. 2007; Graça et al. 2009).

The physical habitat of the locality where *C. semifasciata* was collected in the upper Rio Paraná basin is similar to those within its native range. In the Rio Paraguai and in the middle portion of Rio Paraná, the species inhabits floodplains and is associated with macrophytes (e.g., Suárez et al. 2013) similar to those in streams of the Rio Turvo-Grande sub-basin. Thus, although *C. semifasciata* was only found in a single stream, it probably can spread throughout the basin given the presence of suitable habitat (Casatti et al. 2009). According to Vitule et al. (2009), introductions of non-native fish have multiple negative effects on native faunas, whether or not these species possess attributes typically associated with invasiveness. If *C. semifasciata* in the Ribeirão Buritis, upper Rio Paraná basin, is confirmed to be a recent introduction, it will be important to determine its impact on the region's native fauna and to limit dispersal within the region.

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